DCCUMENT RESUME

ED 036 428 SE 007 741

AUTHOR	KORAN, JOHN J., JR.; AND OTHERS
TITLE	HCW TC USE BEHAVICRAL CBJECTIVES IN SCIENCE INSTRUCTION.
INSTITUTICN	NATIONAL SCIENCE TEACHERS ASSOCIATION, WASHINGTON, D.C.
PUB DATE	69
NOTE	12P.
AVAILABLE FRCM	NATIONAL EDUCATION ASSCCIATION, 1201 16TH STREET, N.W., WASHINGTON, D. C., 20036 (STOCK NUMBER 471-14596, $0.35)
EDRS PRICE	EDRS PRICE MF-$0.25 HC NOT AVAILABLE FROM EDRS.
DESCRIPTORS	AFFECTIVE BEHAVIOR, *BEHAVIORAL OBJECTIVES, COGNITIVE OBJECTIVES, *EDUCATIONAL OBJECTIVES, *ELEMENTARY SCHCOL SCIENCE, PERFORMANCE CRITERIA, PSYCHCMOTOR OBJECTIVES, *SECCNDARY SCHOOL SCIENCE

ABSIRACT

BEHAVICRAL OBJECTIVES SERVE SEVERAL FUNCTIONS: (1) IDENTIFY EXPECTED LEARNER CUTCOMES FOR A GIVEN LESSON OR UNIT OF STUDY, (2) PRCVIDE A BASIS FOR SELECTION AND ORGANIZATION OF MATERIALS AND EXPERIENCES FOR EFFECTIVE LEARNING, (3) PROVIDE A SYSTEMATIC MEANS FOR DEVISING WAYS OF EVALUATING STUDENT PERFORMANCE AND (4) PROVIDE A MEANS TO IDENTIFY THOSE BEHAVIORS THAT CHILDREN ARE ALREADY EXHIBITING PRIOR TO PRESENTING A LESSCN DESIGNED TO PRODUCE BEHAVIORS. WHEN WRITING A BEHAVICRAL OBJECTIVE, ONE MUST USE A SPECIALIZED VERB LIMITED TO FEW INTERPRETATIONS. IT IS IMPORTANT TO DESCRIBE THE SITUATION IN WHICH THE DESIRED BEHAVIOR IS TO BE OBSERVED. THE MINIMAL ACCEPTABLE PERFORMANCE FOR A GIVEN BEHAVIORAL OBJECTIVE MUST BE IDENTIFIED. BEHAVIORAL OBJECTIVES CAN BE WRITTEN FOR DIFFERENT LEARNING OUTCOMES: (1) COGNITIVE LEARNING, (2) AFFECTIVE IEARNING, AND (3) PSYCHCMOTOR LEARNING. (BR)

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USE BEHAVIORAL OBJECTIVES

in science instruction

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SE 007 741

INTRODUCTION

The teacher is a decision maker. Each day many decisions are made regarding what to teach, why to teach it, how to teach it, and how to determine when learning has taken place. In order to make these decisions effectively, the teacher needs many tools. This publication is designed to describe one tool, behavioral objectives; discuss their use; and show their relationship to general instruction. It is meant to accompany and supplement the NSTA monographs, *How to Evaluate Science Learning* (Blackwood and Porter, 1968), *Improving Objective Tests in Science* (Nelson, 1967), and *Behavioral Objectives in the Affective Domain* (Eiss and Harbeck, 1969).[1] We will focus on the theory and functional application of behavioral objectives rather than on particular evaluation techniques. We hope that this approach will provide the teacher with additional information with which he can make more effective decisions.

What Is a Behavioral Objective?

"A behavioral objective is a goal for, or desired outcome of, learning which is expressed in terms of observable behavior or performance of the learner."[2] Before the teacher plans a lesson to be presented to the class, he should have in mind what the students should be able to do or say at the end of the lesson. Ordinarily, the resulting behaviors to be observed at the end of the lesson are either new behaviors or extensions of existing behaviors. For the purpose of this discussion, "behavior" will be defined as what is done or said by a person. For a behavioral objective, the learning outcome specified in the objective will be observable behavior. From this evidence, the teacher will be able to infer the existence of certain types of learning prior to or subsequent to an instructional situation.

What Are the Functions of Behavioral Objectives?

Behavioral objectives can serve several functions. The first of these is the identification of the expected learner outcomes for a given lesson or unit of study. This identification of learner outcomes entails a clear and concise formulation of the behaviors the learner is expected to exhibit after instruction.

A second function of behavioral objectives is to provide a basis for the selection and organization of materials and experiences for effective learning. By stating outcomes in terms of student behavior, the teacher becomes more sensitive to the types of changes he wishes to produce in the learner and the materials and methods most likely to produce these changes.

Behavioral objectives also provide a systematic means for devising ways of evaluating student performance. Since written tests and classroom activities are the major means of evaluating student learning, stating objectives behaviorally serves to guide the teacher in selecting relevant test items and classroom performances with which to measure the learning that has taken place.

Behavioral objectives may be used to identify those behaviors that children are already exhibiting prior to presenting a lesson designed to produce these behaviors. This information alerts a teacher to revise a proposed lesson and focus on those

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[1] See references on page 10.

[2] Montague, Earl J., and Koran, John J., Jr. "Behavioral Objectives and Instructional Design: An Elaboration." TST Forum, *The Science Teacher* 36: 10; March 1969.

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behaviors yet to be attained by various children. This procedure could be thought of as a prediagnosis. In addition, during the presentation of the subsequent lesson, the progress of a class can be continually monitored and the instructional plan modified in accordance with learner progress.

How to Write Behavioral Objectives

The procedure for writing behavioral objectives has been described in several readily available publications. (See Montague and Butts, 1968; Anderson, 1967; Mager, 1962; and Walbesser, 1966.) Consequently, only a brief description will be presented here. Montague and Butts (1968) list the following three parts of an effective behavioral objective: (1) a statement of the behavior desired, (2) a description of the situation in which the behavior is to be observed, and (3) a statement of the extent to which the student should exhibit the behavior. Effective behavioral objectives usually satisfy all three criteria.

When writing a behavioral objective, one must use a specialized verb limited to few interpretations. Such a verb, which precisely describes the desired behavior, gives the teacher a sort of reference point from which he can judge whether the learner has demonstrated the desired behavior. Some examples of these specialized verbs, called action verbs, which correspond with objectives designed to measure thinking are: write, describe, name, identify, predict, infer, select, state, demonstrate, construct, estimate, measure, compare, distinguish, and classify. Another group of verbs which appear to be more appropriate to measuring the degree of student interest, motivation, and values are: select, persist, visit, adopt, accept, and support. Such verbs as understand, know, enjoy, appreciate, and learn are not acceptable for writing behavioral objectives because their meaning is open to many interpretations.

To further sharpen a behavioral objective, it is important to describe the situation in which the desired student behavior is to be observed. This information provides direction concerning what materials and teaching methods may be used to achieve the objective. It also dictates where, how, and under what conditions the objective will be evaluated. Suppose, for example, we wish a student to give the common names of five different types of plants. We must know whether (a) the plants will be presented live for observation; (b) the child will see pictures of the plants in a book; (c) the plants will be described verbally by the teacher; or (d) the student will have to collect the specimens first. If naming the five plants is a desired student behavior, any one of the conditions above would be an acceptable condition under which the desired outcomes could be assessed. Knowing under what conditions an objective was accomplished in earlier teaching sessions is useful if attainment of the objective is to be assured in subsequent sessions. Information about the conditions, when included in the formulation of an objective, communicates clearly and concisely what materials were used during instruction and how they were used by the teacher.

Since there is a range of levels of achievement for any given behavioral objective, the teacher must identify what will be the minimal acceptable performance for that objective. For example, if the objective requires a student to distinguish between statements

of observation and statements of inference, one would ask, "What would be the number of observation or inference statements that the student would have to discriminate between so that the teacher would have evidence that the student had successfully achieved the objective?" Stating minimal acceptable levels of achievement is necessary in order to distinguish between those students who are at one level of achievement and can, therefore, move to a new series of instruction and those who require remedial instruction to establish the prerequisite learning. In addition, levels of achievement provide a criterion for evaluating the success of any given instructional sequence. This type of information is also necessary in order to guide the teacher in determining the depth, breadth, and complexity of topics to be studied. It is recognized, however, that these types of instructional decisions need to be made by the individual teacher working in his particular situation since school populations differ widely, and acceptable criteria for student performance should correspond with student abilities.

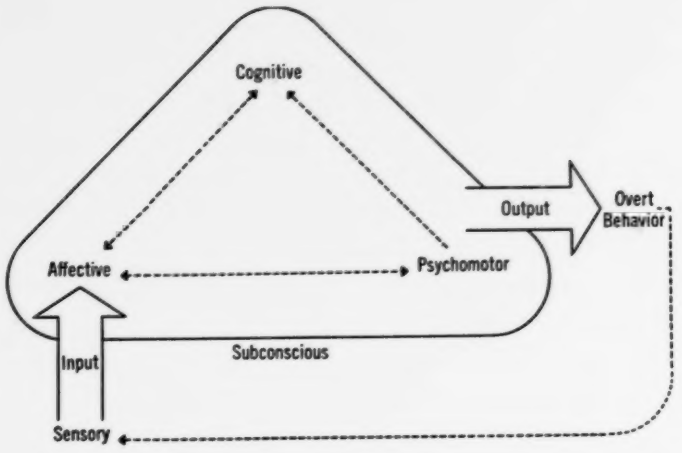
Finally, it should be recognized that writing behavioral objectives is not an end in itself. It is merely a means to the end. Objectives offer a blueprint for some kinds of instruction. Although it is desirable to be able to describe, measure, and replicate behavior, the end product may be effective and efficient student learning or positive changes in attitude. The behavioral objectives then are merely indices of a particular kind of learning.

EXPRESSING BEHAVIORAL OBJECTIVES FOR DIFFERENT LEARNING OUTCOMES

The process of teaching requires that attention be given to three areas of student learning: (1) cognitive learning, (2) affective learning, and (3) psychomotor learning. These can be briefly defined as follows:

1. *Cognitive learning* – Cognitive learning deals with knowledge and understanding. It refers to the recall of concepts and principles. In addition, cognitive learning entails applying the acquired concepts and principles to problem situations and evaluating and synthesizing new concepts and principles from data. (For a further treatment of this subject, see Bloom's *Taxonomy of Educational Objectives, Handbook I,* 1956.)
2. *Affective learning* – Affective learning refers to value, attitude, feeling, and appreciation objectives. This is a particularly difficult area to represent in terms of behavioral objectives because the observable behaviors are open to many interpretations and the teacher makes inferences to decide whether the learning has taken place. (For a more complete treatment of this subject, see Krathwohl, *Taxonomy of Educational Objectives, Handbook II,* 1958, and Eiss and Harbeck, *Behavioral Objectives in the Affective Domain,* 1969.)
3. *Psychomotor learning* – Psychomotor learning refers to the ability to coordinate muscular movement with sensory p ception. It involves simple motor skills like typing and focusing a microscope, as well as skills such as talking and writing (DeCecco, *The Psychology of Learning and Instruction: Educational Psychology,* 1968).

A sensitivity to the cognitive, affective, and psychomotor areas of learning permits the teacher to develop behavioral objectives which sample a wide range of learning outcomes. It also guides the teacher to design instruction so that student intellectual development takes place in each of these areas. The following model (Eiss and Harbeck, 1969) presents an effective way to think of the relationship between these three types of learning.



The authors explain that the baseline in this model is critical. It represents a barrier which they call the "level of awareness" that must be spanned before the mind becomes conscious of a stimulus. As a result of thought, the individual decides whether the stimulus is of interest to him or not. If the stimulus is of interest to him, he will continue to consider it. If it is not of interest, he will reject it. This illustration points out the interplay of the three types of learning very clearly. Decision making, on the part of the student regarding the stimulus, depends to a great extent on the student's values, interests, and curiosity (affective learning). At the same time, the student is making movements relative to the stimulus which could be

thought of as being psychomotor in nature. Finally, active thought about the stimulus and integration of the stimulus into the thought processes could be considered as cognitive activity. When the interplay of these three areas results in new or reorganized information in the individual's memory bank, we may say that learning has taken place. (Eiss and Harbeck, 1969.)

The point here is that learning should take place in each of these areas. The teacher's responsibility is to identify what type of learning is most suitable for a given group of children at a certain time, and then to design instruction in this area and to plan to include the other types of learning when appropriate.

Cognitive Objectives

Levels of learning in the cognitive domain include the following six: knowledge, comprehension, application, analysis, synthesis, and evaluation. Objectives can be constructed for all of them. Knowledge objectives seek to specify simple recall of facts, concepts, and principles. They measure outcomes which are similar to or closely related to the original learning. For example:[3]

1. Presented with ten pictures of animals, previously studied, the student is able to correctly *name* seven out of ten of the animals.
2. Presented with ten pictures of birds and mammals, the student will *divide* the pictures into two groups according to one characteristic as determined by the student. Minimum success would be measured by the classification of eight of the ten pictures.

Comprehension can be described as the ability to make use of communication using the processes of translation, interpretation, or extrapolation. The communication may be one of several forms such as written, oral, visual, or symbolic. The following are two examples of comprehension objectives:

1. When given a table of daily rainfall for a five-day period, the student will state the amount of rain that fell in three days.
2. When given a graph of the growth of a plant over ten days, the student will predict the growth of the plant on the twelfth day, given a steady rate of growth.

[3]Notice that the action verbs are italicized in these examples. Also notice that they differ from later examples in the affective and psychomotor domains.

Curiosity plays an important role in affective learning.

In these cases the degree of success is represented by either the performance or lack of performance of the task. That is to say, the student either can or cannot do the task.

Application is an extension of comprehension in that not only must the learner be able to translate or interpret, but he must also be able to apply the concept or principle to a new situation.

1. After a lesson on the preservation of food, the learner will be able to demonstrate a procedure for retarding or preventing the growth of mold on bread.
2. After a lesson on the characteristics of birds' beaks, the student will, when presented with drawings of their beaks, describe the types of foods five out of ten previously unstudied birds eat.
3. Given a solution of salt and water, the student will be able to devise a procedure for separating the solution into its component parts.

In each of these examples the student has been presented with a problem designed to be slightly different from that presented in class. Therefore, the learner is required to *apply* what he has learned to a different problem situation. Not only is application of knowledge to a new situation being demonstrated here, but also implicit in this application is an initial comprehension of the prerequisite knowledge. The objectives are hierarchical in

nature, moving from simple to complex. Before we can expect a child to perform on a higher level, he must be able to perform the lower level tasks. Analysis objectives call upon the student to identify the parts of ideas or concepts and describe the relationship between the parts.

1. Given popcorn, oil, and a popcorn popper, students will be able to identify one variable which will influence the proportion of kernels of popcorn that pop.
2. Given an article on the migration of polar bears, the student will describe two possible methods of mapping the movement of a particular polar bear.

Synthesis objectives require the student to put together discrete elements into a pattern or structure which the elements did not previously form.

1. Given a graph on the growth of algae in different colored light, the student will state a generalization about light requirements for algae growth.
2. Given seeds which have been grown under various conditions, the student will be able to describe three conditions which appear to be related to optimal growth.

Evaluation objectives elicit from the student a judgment regarding the value of procedures and the imposition of criteria, either imposed by the student or his teacher.

1. After using the English and metric systems for the measurement of various objects, the student will be able to state one commonly accepted advantage of using the metric system.
2. Given newspaper and scientific articles for or against the fluoridation of water, the student will be able to take a position on fluoridation and write three scientific reasons in defense of his position.

Affective Objectives

Affective learning is inferred from behavior which is described by a distinctive group of verbs. This

The number of ways of demonstrating attitudes, values, and interests vary with the individual.

type of learning has been divided into five categories (Krathwohl, 1964): receiving, responding, valuing, organizing, and characterization by value complex. Within each of these divisions, objectives can be formed which seek to engage children in the activities characterized by the category. The behavior which the child will engage in is described by such verbs as selects, supports, advocates, tries, praises. These verbs differ somewhat from the verbs used in cognitive objectives in that they describe a continuum of behaviors rather than a discrete behavior.

Receiving objectives are those which seek to describe a child's awareness of objects or events in his environment, willingness to receive them, and controlled or selected attention to them. Examples of receiving objectives are:

1. After a series of lessons on the live animals in the classroom, the child voluntarily goes to the cages and looks at them.
2. After a series of lessons on the behavior of snakes, the child voluntarily holds a harmless snake in his hands without signs of discomfort.

Responding objectives include those which describe a student's willingness to respond, satisfaction in responding, or acquiescence in responding. Two typical examples of objectives which focus on responding are:

1. When provided with a choice of extracurricular activities to participate in, the child chooses to participate in the science club activities.
2. When live animals are being kept in the room, the child feeds the animals and cleans their cages and appears satisfied with the clean cages.

Valuing objectives are formulated to specify behaviors such as preferences for a value, commitment, and acceptance of a value. Examples of valuing objectives are:

1. During discussions in the science class about natural phenomena, the student asks many questions and often states a preference for scientific explanations.
2. The student reads arguments for and against federal support of scientific research, and writes of his own volition to his Congressman urging legislation in favor of federal support for scientific research.

Objectives which seek to identify behavior that is organizing in nature are those which describe student attempts to conceptualize a value and organize a value system. Two objectives in this area are:

1. Provided with the time and materials, the student will select a scientific topic to explore and participate in research on his own initiative in areas which interest him.
2. Following a series of lessons on pollution, the student identifies a local industry contributing to pollution and formulates a suggested course of action to convince the industry to take precautions against pollution.

Finally, objectives which seek to describe the existence of an internally consistent value complex represent the most complex affective learning level. Examples of objectives on this level are:

1. When in a seminar or small group situation, the student voluntarily and consistently states his reasons for holding a certain view.
2. When presented with a decision involving two courses of action, the student chooses that one which is supported by data or evidence or is unwilling to make a choice when evidence is ambiguous.

The above objectives each have a set of conditions specified and the performance to be observed specified. They do not include a clear-cut criterion level for performance. There are a number of reasons for this. One major reason is that affective objectives are themselves value-laden. They vary greatly with the individual, the subject area, the school, and the social situation. Consequently, these objectives should be thought of as open-ended in nature. Evidence of their achievement will be considered in terms of relative degrees, because the number of types of ways of showing interest, values, or attitude vary with the individual. Intensity of behavior also varies with the individual. The teacher should consequently be very cautious not to impose, or expect, rigid conformity to any one affective objective, but rather a varying pattern of conformity for each student and a varying intensity of conformity within this pattern. A major concern of the teachers within this framework is to provide the opportunity for individual expression and variation to occur.

Psychomotor Objectives

Objectives in this area seek to describe performance of a wide variety of skills which are dependent on physical ability. We must think of a skill as performance of a specific task in science.

For instance, focusing a microscope or dissecting an organism are skills which depend on the basic

psychomotor abilities of manual dexterity and motor coordination. Abilities under these circumstances are general in nature and may apply to a wide range of skills. Fleishman (1964) has described fourteen physical abilities which he groups in the following six broad areas: strength, flexibility, speed, balance, coordination, and endurance. For each of these areas, he provides a description of the component abilities and the possible tests of performance. Some examples that may be related to science instruction are:

Balancing objects: The ability to balance objects when presented with the objects and instructions.
Objective: When presented with two objects, the child will balance one object on the back of each hand.
Multilimb coordination: The ability to coordinate the simultaneous movement of two appendages.
Objective: Presented with a microscope to focus and a specimen to draw, the child will draw the specimen while focusing the fine adjustment.

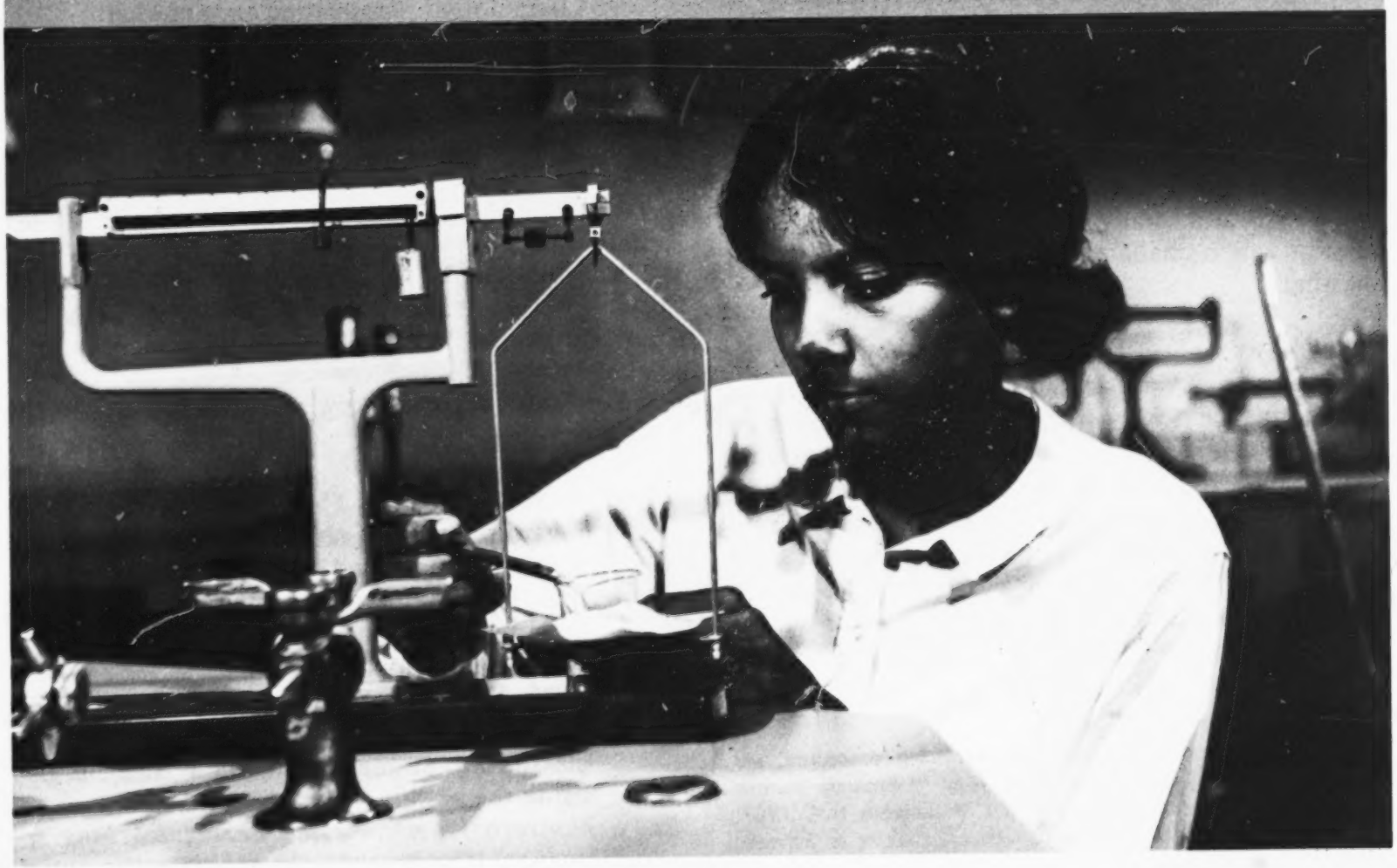
Psychomotor performances are important to other types of learning. For instance, if the child cannot focus a microscope due to a lack of coordination, or cannot dissect an organism when given instructions, it is difficult for some cognitive processes to take place, and, accordingly, interest and motivation are influenced. Consequently, it is important for children to develop at very young ages the simple psychomotor skills necessary for further physical and mental development. At the same time, a teacher must consider whether deficiencies in certain psychomotor skills are influencing other types of learning. Poor hand-to-eye coordination may very well be the reason why a drawing is inaccurate or a dissection poor. The psychomotor area must constantly be kept in mind when instructional plans are being developed or deficiencies in performance are observed.

USING BEHAVIORAL OBJECTIVES

Once desired learning outcomes have been stated in each of the areas described, the identification of various effective strategies of teaching and the selection of materials for instruction are easier. The use of behavioral objectives also provides for the identification of evaluation methods which permit assessment of the teaching methods and behavior employed, in terms of the resultant student learning.

The following chart illustrates how a series of test items may be analyzed to determine whether there

Many skills depend on the ability to coordinate physical movements, such as in balancing or weighing materials.



is a balanced emphasis within a domain – in this instance, the cognitive. The same type of chart could be used for the affective and psychomotor areas by modifying the categories at the top of the chart. Such a chart is useful in determining whether there is an equal distribution of learning tasks, when the teacher is selecting content and evaluating instruction.

Classifying Test Items by Objectives Category[4]

Questions	Cognitive Domain					
	Evaluation	Synthesis	Analysis	Appli-cation	Compre-hension	Knowl-edge
1		X				
2			X			
3	X					
4				X		
5						X
6		X				
7					X	
8			X			
9	X					
10						X
11					X	
12				X		

A chart of this type can also be used by the teacher to keep track of the categories and frequencies of questions he asks in class. It is quite important to recognize that if a student is to perform at higher levels of learning after instruction than he did before instruction, he must have experiences in class which permit this type of performance. These conditions can be arranged only if the teacher is aware of, and plans, questions during class discussion which challenge children to higher levels of learning.

The following sequence is one which could be followed when a particular science objective is the goal of instruction. Although the achievement of all three categories or domains of learning could conceivably be realized by the same lesson, this lesson will exemplify an instructional program using cognitive objectives and examples. The same plan could be used for a corresponding set of affective or psychomotor objectives.

1. Identification of the major goals of science instruction at a certain grade level and for certain types of students

   Example: The students should become familiar with the role of classification in science.

2. Development of a list of behavioral objectives which apply to the overall goal

   Example: Presented with ten pictures of animals, the student will:

   a. Identify characteristics of each animal;
   b. Place the animals into groups according to characteristics the student identified;
   c. Describe his own system for classification.

   The criterion in each case is whether or not the child can perform.

3. Planning teaching strategies to achieve these objectives

   Example:

   a. Present the class with pictures or photographs of animals;
   b. Ask the class to identify the distinguishing characteristics and name each animal;
   c. Have the class place pictures in groups according to some system;
   d. Discuss grouping of pictures with the class;
   e. Pass out new sets of pictures to individual students,
   f. Have the students place pictures in groups according to a system the student devised;
   g. Discuss with the class as a group the various systems they devised for classifying the animals.

4. Methods of evaluating the attainment of the objective:

   a. *Class discussion:* The extent of knowledge regarding the classification system and the characteristics used for classification of animals could be determined by the verbal responses of the students to teacher and student questions.
   b. *Written report:* Students could be asked to write a report describing their system of classifying animals and their reasons for using the system.
   c. *Nonverbal performance during teaching sequence:* The teacher can monitor the activi-

[4]For a more elaborate discussion of evaluation procedure, see Blackwood, Paul E., and Porter, T. R. *How to Evaluate Science Learning in the Elementary School.* NSTA, Washington, D. C. 1968; and Nelson, Clarence H. *Improving Objective Tests in Science.* NSTA, Washington, D. C. 1967.

Writing clear, specific objectives will lead to more accurate means of evaluating their attainment.

ties of students in the classroom to determine how accurately they are grouping the animals.

d. *Test items presented following teaching sequence:* In designing test items, it is important to consider the level of learning the teacher desires children to demonstrate. Any of the six levels of cognitive learning could be evaluated by the use of a given test item. Affective and psychomotor test items might be in the form of observation checklists.

5. Feedback and revision:

An important part of an instructional plan is the feedback and revision component. If, for example, only 10 percent of a class were able to achieve certain objectives on a measurement scale, the teacher should go back over his procedures and use this feedback (test results) to revise or modify his activities. Perhaps the objective was too difficult, or the teaching method inappropriate. It may be that his test items were not sensitive enough to measure certain objectives, or that the sequence of objectives was not the most effective for learning. It is also possible that the needs and goals from which the objectives were derived require reassessment. Feedback, then, constitutes a very important type of instructional information which the teacher should always seek. It may be in the form of test scores, written or oral interviews, or direct classroom observation. But, whatever the *form,* it should be acted upon in order to optimize instruction.

A format similar to the aforementioned one could be constructed for affective and psychomotor objectives if it is found that all three types of objectives were not achieved in one lesson format.

The teaching plan would include: (1) identification of the major needs and goals in science; (2) development of behavioral objectives; (3) planning content and teaching strategies to achieve the goals; (4) evaluating the attainment of objectives; and (5) feedback and revision.

Test items or performance checklists could be devised and used to plan for and assess the achievement of affective or psychomotor objectives. The following performance checklist provides a way to record the occurrences of affective and psychomotor performances when they occur in the classroom:

A PERFORMANCE CHECKLIST

	Not Observed	Observed
Affective Performances		
Example: Shows interest		X
Psychomotor Performances		
Example: Focuses microscope	X	

In the above instructional sequences there are many considerations beyond those stated. Establishing goals and assessing needs for science instruction require serious consideration of their relevance to the student, school, community, and society. This whole approach to designing and using instructional objectives would be of little worth if one began with trivial goals.

At the same time, the behavioral objectives stated should sample important outcomes which are directly derived from the general goals. Since it is not feasible to write behavioral objectives for all of the possible outcomes of any learning sequence, it is important that the teacher attempt to focus on a balanced sample of possible behavioral outcomes.

Teaching strategies vary with the teacher's personality, the type of students, and the physical surroundings. Nevertheless, it is important to provide experiences on a number of levels and in a multitude of ways so that a range of thinking will occur in the class. The behavioral objectives stated should guide the teacher in his selection and sequencing of content and teaching strategies.

Many times there is a tendency to state behavioral objectives to promote learning beyond that of factual recall, and then to reduce these objectives to memory outcomes during the teaching process. An objective such as "evaluating a system" is reduced to the rote memorization of stating the steps in the evaluation or of repeating an evaluation made by others, rather than actually devising an evaluation procedure. For this reason, when student performance is being evaluated, an initial objective should be projected to a number of levels of abstraction and should be demonstrated in a multitude of contexts in order to get evidence of higher levels of student learning.

Summary

This discussion has attempted to develop a theoretical orientation and to describe some practical guidelines for the use of behavioral objectives in science instruction. An important emphasis is on what the child does or says as he learns science. Behavioral objectives permit the teacher to focus more closely on children's behavior rather than on the impersonal concern for content alone. In spite of the many possible limitations of the use of behavioral objectives, the benefits derived from this concern for the child clearly justify their inclusion as an effective tool in the teacher's repertoire of skills.

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